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## REMARKS

Status of the Case:

The present invention provides methods for producing *in-situ* composite solders having particulate intermetallics homogeneously distributed throughout the solder matrices. The composite solder is made by mixing a conventional solder with the components of the intermetallic phase, heating the mixture until all components are melted, and rapidly cooling. The solders of this invention provide greater solder joint strength and fatigue resistance than solders among those known in the art.

In the Office Action issued January 29, 2003, all claims were rejected under 35 U.S.C. §102 and/or §103. In this amendment, independent Claims 26, 42, and 53 are cancelled, and replaced with new independent Claims 59, 60, and 61, respectively. Support for the subject matter of new Claims 59, 60, and 61 is found, *inter alia*, in the specification on page 9, lines 13-17, and page 11, lines 16-20, and in the claims as filed. The dependencies of Claims 27, 34, 37, 41, 43, 47, 52, 53, and 56 are amended, accordingly. Other conforming language changes are made in dependent Claims 47 and 56. New dependent Claims 62-77 are added. Former dependent Claims 38-40, 42, 49-51, and 53 are cancelled. After this amendment, Claims 27-37, 41, 43-48, 52, and 54-77 are pending.

*Anderson* neither anticipates nor renders obvious Applicant's invention.

The Examiner rejected Claims 26-30, 33-36, 38-48, and 50-58 under 35 U.S.C. § 102(b) as anticipated by or, in the alternative, under 35 U.S.C. §103(a) as obvious over U.S. Patent 5,527,628, Anderson et al., issued June 18, 1996. The Examiner states that, "The Anderson et al. reference discloses the features including steps of combining a solder with the components of the

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intermetallic phases such as Cu and Ag to form a mixture... . ... Anderson et al. do not disclose the claimed cooling rate and do not explicitly disclose to add an intermetallic component separately from the solder alloy." In responding to Applicant's previous arguments regarding *Anderson*, the Examiner further states, "Therefore, it is contemplated [to be] within [the] ambit of [an] ordinary skill[ed] artisan to use commercially available Sn-Ag solder as starting material to combine with Cu. Moreover, it is well settled that the form of reactants is believed mere[ly] a choice between well known forms of such substances. In the absence of evidence of some unobvious aspect of their selection, use of those substances would seem to add nothing of patentable significance to the instant claims. " Applicants respectfully traverse this rejection.

As quoted above, Examiner recognizes that *Anderson* does not disclose the claimed cooling rate and does not disclose the addition of an intermetallic component to a conventional solder alloy. To the extent that the Examiner is relying on inferences or inherency to support anticipation, the Examiner must provide a specific rationale to support a rejection of novelty. Lacking such support, the rejection under §102 must fail.

Focusing more closely on the specific teachings of *Anderson*, it is clear that no such inferences can possibly be drawn from *Anderson.* Rather, there are fundamental differences between the compositions of *Anderson* and those of the Applicants that render the present invention both novel and non-obvious. It is apparent from the discussion of the art in *Anderson* that a key focus of *Anderson* is the melting temperature of the solder composition in-use. See, *Anderson*, at column 1, line 39 through column 2, line 8. In this discussion, *Anderson* characterizes several prior art compositions as having melting temperatures that are too high for use in electronic soldering. Accordingly, *Anderson* defines a very specific solder composition comprising 93.6 weight percent tin, 4.7 weight percent silver, and about 1.7 weight percent

copper, having a eutectic melting temperature of about 217°C. *Anderson*, at column 2, lines 41-46. The term "eutectic" is defined as the lowest melting point of an alloy or solution of two or more substances that is obtainable by varying the proportion of the components. Eutectic alloys have definite and minimum melting points in contrast to other combinations of the same metals." Hawley's Condensed Chemical Dictionary, 13th edition (1997), copy attached.

The Examiner's rejection implies that *Anderson* broadly teaches the addition of copper to a silver tin alloy. This is clearly not the case. Addition of copper beyond the very limited amount disclosed in *Anderson* would inherently change the melting point of the composition, resulting in a non-eutectics solder. The melting point would increase, which is manifestly contrary to *Anderson's* objective.

This distinction between *Anderson* and Applicant's invention is underscored in new independent Claims 59-61 in two different ways. First, as noted in Claims 59 and 61, Applicants add an intermetallic component to a eutectic or near eutectic solder. Inherently, then, the resulting solder has a stoichometric composition which is non-eutectic. Secondly, the quantity of a copper-containing intermetallic component in copper-containing embodiments of Applicant's invention would be significantly higher than the amount of copper in the *Anderson* composition. (It must be noted many embodiments of Applicant's invention do not use a copper-containing intermetallic.) As set forth in the following calculation, a composite solder consisting of the eutectic solder of *Anderson* plus 5 volume percent of a $Cu_6Sn_5$ intermetallic will have a total copper concentration of over 2.2 weight percent. This far exceeds the copper concentration of *Anderson*, and renders the Applicant's composition non-eutectic. The effect of this increased amount of copper is seen in the attached phase diagram from Smithells Metals Reference Book, 7th edition, Butterworth Heinemann, Oxford, 11-242 (1992). As indicated, a 5 volume percent

col. 2 lns 60-65

$Cu_6Sn_5$ intermetallic would raise the liquidus temperature to approximately 285°C, well above the asserted 217°C melting temperature asserted for the *Anderson* solder.

In sum, *Anderson* teaches the production of a narrowly defined eutectic tin solder. Applicant's methods, by contrast, start with a eutectic solder and add an intermetallic component thereby forming a non-eutectic solder (for embodiments comprising copper) having copper concentration significantly higher than those of *Anderson*. Accordingly, Applicant's methods are both novel and not obvious. Applicants respectfully request that rejection over *Anderson* be withdrawn.

<u>Applicant's invention is not obvious from the combination of *Anderson* with the Gibson reference.</u>

Examiner rejected Claims 37 and 49 under 35 U.S.C. §103(a) as being unpatentable over Anderson in view of Gibson et al., "Issues Regarding Microstructural Coarsening Due to Aging of Eutectic Tin-Silver Solder," <u>Design and Reliability of Solders in Solder Interconnections,</u> 97-103 (1997). The Examiner alleges that it would have been obvious to combine the teachings of *Gibson*, which shows a solder having a 20 volume percent intermetallic phase, with *Anderson*. Applicants respectfully traverse this rejection.

As discussed above, *Anderson* discloses a very specific narrowly defined eutectic solder composition. *Anderson* teaches away from any modification of that solder, given its objective to form a solder having a low melting temperature. Addition of even a 5 percent intermetallic phase, as shown above, results in a composition having significantly higher levels of copper (for embodiments having copper) than those of *Anderson*, having a non-eutectic nature. Compositions such as those of *Gibson,* with even higher volume percents of intermetallics,

would necessarily be even farther away from those of *Anderson*. In particular, a composition having 20 volume percent $Cu_6Sn_5$ would have approximately 8.6 weight percent copper, and a liquidus temperature of well over 400°C (as seen from the attached phase diagram). Accordingly, not only is there a lack of motivation to combine these references, *Anderson* actually teaches away from such a combination. The methods of Claims 37 and 49 are, accordingly, not obvious. Applicants respectfully respect withdrawal of the rejection based on *Anderson* and *Gibson*.

<u>Applicant's invention is also non-obvious from *Anderson* in view of the Lucey reference.</u>

The Examiner also rejected Claims 31 and 32 under 35 U.S.C. §103(a) as being unpatentable over *Anderson* in view of U.S. Patent 5,520,752, Lucey, Jr. et al., issued May 28, 1996. The Examiner alleges that it would have been obvious to use the different intermetallic phases disclosed in *Lucey* in combination with *Anderson* to form the Applicant's invention. Applicants respectfully traverse this rejection.

As discussed above, *Anderson* teaches away from any attempt to modify its narrowly-defined eutectic solder composition. It would not have been obvious to add any intermetallic to the composition of *Anderson*, because doing so would have inherently resulted in a non-eutectic solder. In contrast to *Anderson*, *Lucey* adds filler particles to a commercial bulk or paste solders. *Lucey*, at column 2, lines 12-16. Unlike Applicant's methods, however, *Lucey* does not disclose melting the components of the interparticulates so as to form a liquid mixture of the solder and the intermetallics. This is clear, for example, from the discussion at *Lucey*, column 3, lines 35-40, which discusses alteration of the shape and dimension of the added particles-- which would

be irrelevant if those particles were melted in the manufacturing process. This is also apparent from the process described in the example on Column 4 of *Lucey*.

Accordingly, the combination of *Lucey* and *Anderson* does not teach Applicant's process of adding the components of the intermetallic to a solder, melting the solder and the components, and rapidly cooling so as to form a very fine particulate intermetallic. Applicant's methods are not obvious from the combination of *Anderson* and *Lucey*. Applicants respectfully request withdrawal of the rejection.

<u>Summary</u>

Applicants respectfully submit that the rejections of record are improper, as being based on a reference (*Anderson*) which teaches only the production of narrowly-defined eutectic solders. Adding intermetallics to such a eutectic solder, as required in Applicants' methods, would result in compositions that are non-eutectic, and compositionally much different than those of *Anderson*. The secondary references, *Gibson* and *Lucey*, do nothing to remedy these deficiencies. Moreover, there is no motivation to combine these references. Accordingly, Applicant's compositions are novel and non-obvious. Applicants respectfully request withdrawal of the rejections of record and allowance of all claims.

Respectfully submitted,

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Attachment

Phase Diagram

Sn-3.5Ag-0.7Cu eutectic solder having 5% and 20% (by volume)$Cu_6Sn_5$

Phase diagram is adapted from Smithells Metals Reference Book, 7th ed., Butterworth Heinemann, Oxford, 1992, p. 11-242)